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Evaluation of chest radiography and low-dose computed tomography as valuable screening tools for thoracic diseases

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Abstract

Background: Recent studies have shown that low-dose computed tomography (LDCT) is effective for the early detection of lung cancer. However, the utility of chest radiography (CR) and LDCT for other thoracic diseases has not been as well investigated as it has been for lung cancer. This study aimed to clarify the usefulness of the veridical method in the screening of various thoracic diseases.

Methods: Among individuals who had received general health checkups over a 10-year period, those who had undergone both CR and LDCT were selected for analysis. The present study included 4317 individuals (3146 men and 1171 women). We investigated cases in which abnormal opacity was detected on CR and/or LDCT.

Results: A total of 47 and 124 cases had abnormal opacity on CR and LDCT, respectively. Among these, 41 cases in which the abnormal opacity was identified by both methods contained 20 treated cases. Six cases had abnormalities only on CR, and none of the cases required further treatment. Eighty-three cases were identified using LDCT alone. Of these, many cases, especially those over the age of 50 years, were diagnosed with thoracic tumors and chronic obstructive pulmonary disease, which required early treatment. In contrast, many cases of pulmonary infections have improved spontaneously, without any treatment.

Conclusion: These results revealed that LDCT allowed early detection of thoracic tumors and chronic obstructive pulmonary disease, especially in individuals over the age of 50 years. CR is still a useful imaging modality for other thoracic diseases, especially in individuals under the age of 49 years.

Abbreviations: BOOP = bronchiolitis obliterans organizing pneumonia,COPD = chronic obstructive pulmonary disease,CR = chest radiography,DR = detection rate,IPF = idiopathic pulmonary fibrosis,LAM = lymphangioleiomyomatosis,LDCT = low-dose computed tomography,PAH = pulmonary arterial hypertension,UGI = upper gastrointestinal series.

Keywords: chronic obstructive pulmonary disease, computed tomography, lung cancer, pulmonary infection, radiography, screening, thoracic disease

1. Introduction

Chest radiography (CR) is the most common imaging modality used to detect thoracic diseases.[1] It is widely available and incurs lower radiation exposure than that associated with other imaging tools such as computed tomography (CT). The recently developed automated analysis of CR can help in population screening during health checkups and assist pulmonologists and radiologists in interpretation and triaging, thereby easing their workload.[2,3] However, CR has a lower sensitivity than CT. In fact, CR is usually an ineffective screening modality for the detection of lung nodules that are less than 10 mm, and lung cancers detected using this method usually progress to the advanced stage.[4,5] A recent randomized controlled trial on lung cancer screening by CR also did not show a reduction in mortality compared to that with usual care.[6] These results suggest that CR is not a useful modality for screening lung cancer.

In 2011, the National Lung Screening Trial reported that adherence to a protocol of annual low-dose computed tomography

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All data generated or analyzed during this study are included in this published article (and its supplementary information files).

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(LDCT) lung cancer screening and follow-up reduced lung cancer mortality by 20% compared to CR screening in smokers.[7] This study is the first large randomized trial to demonstrate the efficacy of CT in lung cancer screening. However, a recent population-based study identified a key problem in implementing LDCT screening, as used in the trial setting, in everyday practice.[8] The prevalence of CT screening among eligible people in the United States has remained virtually stagnant over the past few years: 3.3% in 2010 and 3.9% in 2015, and the majority of cigarette smokers continue to undergo screening with CR rather than LDCT.[8,9] The acceptance rate of LDCT for lung cancer screening is much lower than that of other disease screening tests; for example, more than half of the eligible women attend screening mammography in developed countries.[10]

On the other hand, Japan has its own medical checkup system, and most of the people on working-age generation (aged 18–64 years) take a systemic medical examination every year. However, LDCT is not routinely recommended for initial assessment in health checkups in Japan, and there is still no consensus on this.

CR and LDCT should also be important modalities for other thoracic diseases such as infectious diseases, other thoracic tumors, chronic obstructive pulmonary disease (COPD), and cardiovascular disease. In particular, there are a considerable number of people diagnosed with COPD and infectious pulmonary disease during health checkups. Nevertheless, the usability of CR and LDCT for screening other thoracic diseases has not been investigated as well, as it has been used lung cancer. Therefore, the aim of this study was to clarify the usefulness of CR and LDCT as valuable screening methods for all thoracic diseases, which leads to a definitive way.

2. Methods

2.1. Subjects

This cross-sectional study enrolled 639,758 individuals who underwent a general health checkup at our facilities (Health Care Center, 7th floor Shinjuku Oiwake Clinic and 6th floor Ladies Branch, Seikokai, Shinjuku-ku Tokyo, Japan) over a 10-year period from April 1, 2010, to March 31, 2020. Of these, 635,441 individuals underwent CR only and were excluded from this study. A total of 4317 remaining individuals were undergone both CR and chest LDCT and finally included in this study, containing 3146 men (aged 14–75 years, mean ± standard deviation = 48.0 ± 10.1 years) and 1171 women (aged 24–75 years, mean ± standard deviation = 48.8 ± 10.2 years). Of these individuals, 1847 were aged ≥50 years (1330 men and 517 women) and 2470 were ≤49 years old (1816 men and 654 women). We investigated the number of cases of abnormal opacity that warrant further examination on CR and/or LDCT. We categorized the cases detected on both CR and LDCT as Group 1, detected only on CR as Group 2, and detected only on LDCT as Group 3. We also analyzed how many cases finally received meaningful treatment, were followed up, or improved in each group. A flowchart of the case selection and sample grouping methods is presented in Figure 1.

2.2. Ethical principles

The present study was conducted in accordance with the Declaration of Helsinki, and the study protocol was approved by the Seikokai Group Ethics Committee (Ethics Committee Number O15-01). Informed consent was obtained during the health checkups at our facilities.

2.3. Methods

CR examination was performed using a digital radiography machine (CALNEO PU; Fujifilm, Tokyo, Japan) at a dose of 100 mA at 120 kV. Posteroanterior images were obtained with individuals in the standing position during the inspiratory breath-holding phase. CT examinations were performed using a 4-row helical CT scanner (ROBSTO; Hitachi, Tokyo, Japan) from April 2010 to April 2018 and a 64-row helical CT scanner (SUPRIA GRANDE; Hitachi) from May 2018 to March 2020 with the same conditions of 50 mA at 120 kV and without contrast medium, and 5-mm axial images were acquired.

Interpretation of CR and LDCT findings was performed independently with double-checking or triple-checking, where appropriate by at least 1 pulmonologist, radiologist, or internal medicine specialist. If there were discrepancies between the interpretations, the final decision was made by a pulmonologist or radiologist. The individuals who were required to undergo further examination were referred to specialists, and a final diagnosis and treatment were carried out by internal or external chest medicine specialists. The clinical course of each case was cooperated with hospitals, and the outcome of the case (i.e., medication and operation) was provided feedback to the outpatient clinic. The remaining individuals who did not undergo treatment were followed up periodically by their hospital or clinic according to their improvement, no change, or absence of abnormalities.

3. Results

3.1. Group comparisons

Among 4317 individuals, 47 cases (1.1%) with abnormal opacity on CR and 124 (2.9%) on LDCT required further examination (Fig. 2). The detection rate (DR) of each method is almost equivalent to that reported in our country.[11] There were 41 cases (Group 1) in which abnormal opacity was identified by both methods (Fig. 2). The characteristics of group 1 are listed in Table 1. Finally, 20 cases required medical treatment; of these, there were 10 cases of pulmonary infection, 6 cases of thoracic tumor, 1 of COPD, 1 of bronchiolitis obliterans organizing pneumonia (BOOP), 1 of pulmonary arterial hypertension (PAH), and 1 of cardiomyopathy. A summary of the 20 cases is presented in Table 2. Half of the cases (n = 10) had pulmonary infections (Cases 1–10). In contrast, 19 cases did not require medical treatment (Table 1).

Six cases were detected only in the CR group (Group 2). The characteristics of group 2 cases are shown in Table 3. All 6 cases were followed up or were cases with no abnormalities, and no cases requiring treatment were identified in this group.

Eighty-three cases were detected only on LDCT (Group 3). The characteristics of group 3 cases are shown in Table 4. Finally, 30 cases included 12 cases of pulmonary infection, 10 cases of thoracic tumor, 5 of COPD, 1 of lymphangioleiomyomatosis (LAM), 1 of idiopathic pulmonary fibrosis (IPF), and 1 of pulmonary sequestration requiring medical treatment. A summary of the 30 cases is presented in Table 5. As can be seen, LDCT is useful in the detection of many cases of pulmonary infection, thoracic tumors, and COPD that require medical treatment. In contrast, 47 cases did not require any medical treatment (Table 4), and the number of these cases was also much higher than that in group 1 (n = 19).

3.2. Detection of pulmonary infection

The most commonly detected abnormal lesion was pulmonary infection, and 43 cases were identified by CR and/or LDCT (Tables 1 and 4). Pulmonary infection cases were distributed across various generations (n = 19; ≤ 49 years and n = 24; ≥ 50 years). Among them, 14 were in group 1 and 29 were in group 3. However, in 17 group 3 cases, treatment was unnecessary due to spontaneous improvement or old inflammatory changes.

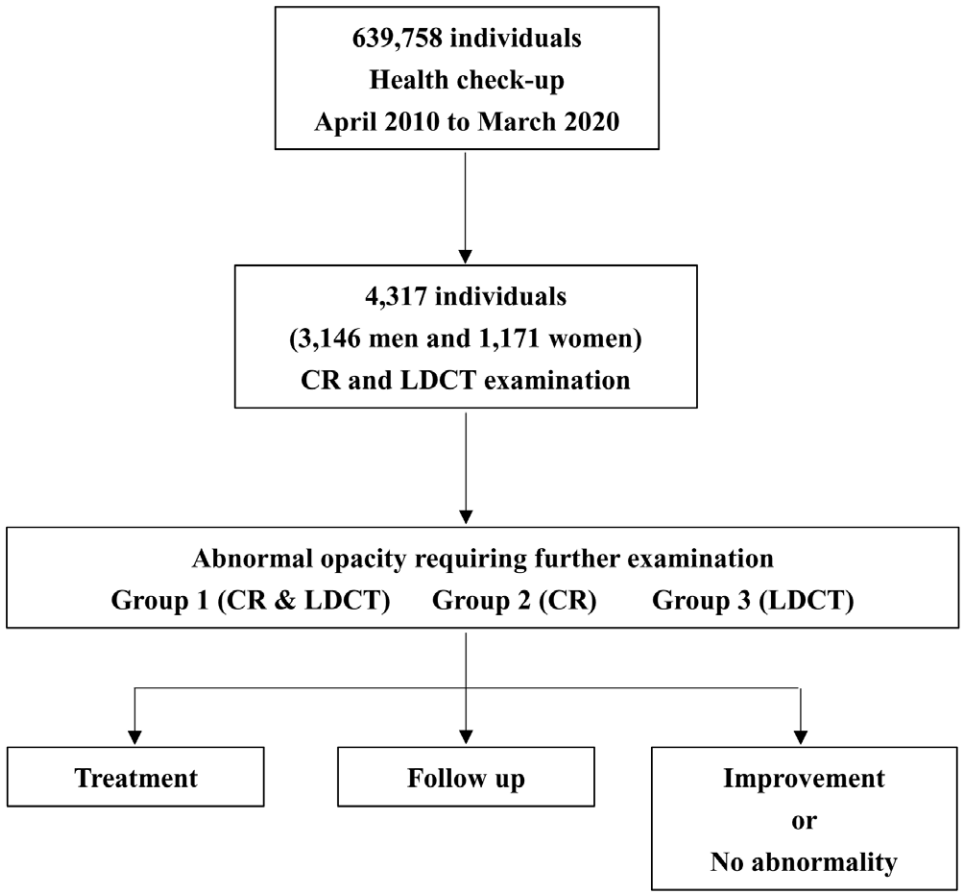

Figure 1. Design and flow of this study. CR = chest radiography, LDCT = low-dose computed tomography.

Twelve remaining cases were treated with antibiotics, and many of these cases (Table 5; Cases 1–9) were of community-acquired pneumonia; all cases received oral antibiotics as outpatient care. There were 2 cases of tuberculosis (Table 5; Cases 10 and 11) and 1 case of pneumomycosis (Table 5; Case 12) that required specific antibiotic treatment.

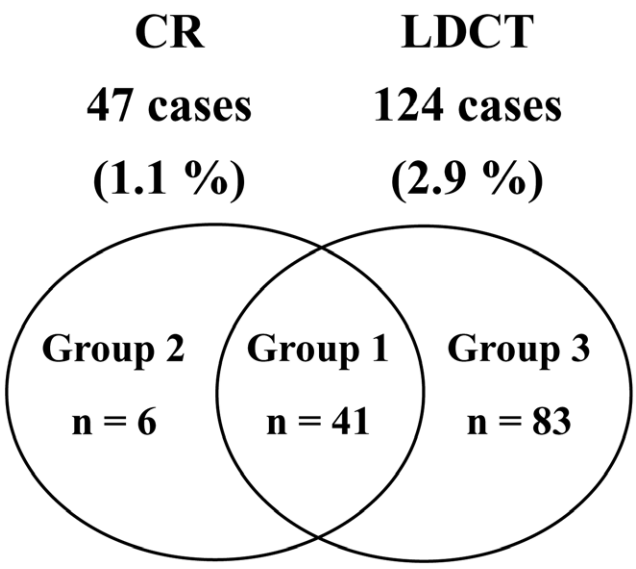

Figure 2. Abnormal opacity cases requiring further examination detected by CR and/or LDCT. CR = chest radiography, LDCT = low-dose computed tomography.

3.3. Detection of thoracic tumors

In total, 17 cases of thoracic tumors were identified using CR and/or LDCT (Tables 1 and 4). Among them, 7 cases were in group 1, and 10 were in group 3. The DR for thoracic tumors was 0.16% (7/4317) for CR and 0.39% (17/4317) on LDCT. LDCT helped in detecting 10 thoracic tumors within the CR-negative phase, and 7 of these 10 cases (Table 5; Cases 13–19) were finally diagnosed as malignant tumors. Fortunately, these 7 cases were found to be early stage tumors and could be treated with thoracoscopic surgery. One of these cases is shown as an example (Table 5; Case 15) in Figure 3A and B. In this study, we found that many thoracic tumor cases were detected in those aged ≥50 years (Tables 2 and 5; n = 12), and among individuals of this age group (n = 1847), the DR of thoracic tumors using LDCT was extremely high (12/1847 = 0.65%). Of these 1847 individuals, 638 were current smokers and 1209 were not current smokers; however, the DR of thoracic tumors among nonsmokers (7/1209 = 0.58%) was still high, similar to that of smokers (5/638 = 0.78%).

In terms of lung cancer, only 2 cases were identified on CR (Table 2; Cases 11 and 12) and 6 cases (Table 5; Cases 13–18) were detected on LDCT alone. This result indicates that the DR of lung cancer with LDCT (8/4317 = 0.19%) was much higher than that with CR (2/4317 = 0.05%). For individuals aged ≥50 years (n = 1847), the lung cancer DR with LDCT was also high (6/1847 = 0.32%).

In contrast, 12 cases of benign pulmonary nodules were found using LDCT alone (Table 4), which needed to be followed up periodically. The number of such cases was much higher than that detected using CR (n = 4; Table 1). Additionally, 6 cases of mediastinal benign nodules and lymphadenopathy were found

Table 1

Characteristics of 41 cases in group 1.

Clinical course	Diagnosis	n	M/W
Treated cases (n = 20)	Pulmonary infection (n = 10)		
	Pneumonia	7	5/2
	Tuberculosis	2	2/0
	MAC	1	0/1
	Thoracic tumor (n = 6)		
	Lung cancer	2	2/0
	Mediastinal tumor	2	1/1
	Diaphragmatic sarcoma	1	0/1
	Pleural mesothelioma	1	0/1
	COPD	1	1/0
	BOOP	1	1/0
	PAH	1	0/1
	Cardiomyopathy (cardiomegaly)	1	1/0
Follow-up cases (n = 16)	Pulmonary nodule	4	3/1
	Pleural thickening	1	0/1
	Cardiomegaly	2	2/0
	Pulmonary infection	2	1/1
	COPD	4	4/0
	Bulla	2	1/1
	Thoracic tumor (mediastinal tumor)	1	1/0
Improvement cases (n = 2)	Pulmonary infection	2	2/0
No abnormality (n = 1)		1	0/1
Unknown cases (n = 2)		2	2/0
Total		41	29/12

BOOP = bronchiolitis obliterans organizing pneumonia, COPD = chronic obstructive pulmonary disease, M = men, MAC = *Mycobacterium avium* complex, PAH = pulmonary arterial hypertension, W = women.

on LDCT alone (Table 4). In total, 18 cases needed to be followed up periodically on LDCT screening alone.

3.4. Detection of COPD

In total, 13 cases with initial emphysematous changes were detected using CR and/or LDCT (Tables 1 and 4). Among them, we found 8 cases of low attenuation area, which is an incipient sign of COPD, using only LDCT (Group 3); this allowed early detection and implementation of smoking cessation treatment (Table 5; Cases 23–27). An example case (Table 5; Case 24) is shown in Figure 4A and B. The DR with CR was 0.12% (5/4317) and that with LDCT was 0.30% (13/4317). The DR was higher than that in lung cancer (0.19%). For individuals aged ≥50 years (n = 1847), the DR with LDCT was also remarkably high (10/1847= 0.54%).

3.5. Detection of other thoracic diseases

We also detected other thoracic diseases such as bulla, BOOP, IPF, PAH, tracheal polyp, atherosclerosis, and cardiomegaly using CR and/or LDCT. Among the cases of cardiomegaly, 3 cases were in group 1, 1 case was in group 2, and no case was in group 3 (Tables 1, 3, and 4). This result means that CR could detect 1 more case of cardiomegaly compared to LDCT.

Among the 6 cases who required medical treatment (Table 2; Cases 18–20 and Table 5; Cases 28–30), 1 case each of BOOP, PAH, and cardiomyopathy was in group 1, and 1 case each of LAM, IPF, and pulmonary sequestration was in group 3; however, the number of cases requiring treatment was relatively lower than that for pulmonary infection, thoracic tumors, and COPD.

4.Discussion

The utility of CR and LDCT as screening tools has long been debated and remains controversial. The majority of previous studies have mainly focused on lung cancer and its prognosis because lung cancer is aggressive, is heterogeneous, and has a poor prognosis.[12–14] Lung cancer is the leading cause of cancer-related deaths in both the United States and Japan, despite its lower incidence compared to those of other major cancers such as gastric, colorectal, and prostate cancer in men and breast cancer in women (National Cancer Center Japan Report 2019: http//ganjoho.jp/reg_stat/statistics/stat/summary.html).[5] Therefore, early-stage detection of lung cancer during health checkups is important for prompt surgical resection and reduction of cancer-related deaths. On the other hand, other thoracic malignancies, such as mediastinal malignant tumors (i.e., thymic cancer and liposarcoma) and pleural mesothelioma, also have a poor prognosis as well as lung cancer.[15–17] In addition, we found an equivalent number of other thoracic tumors (n = 9) as well as lung cancer (n = 8)

Table 2

Summary of 20 cases in group 1 who received medical treatment.

Case (n)	Age (yr)	Sex (M/W)	Diagnosis	Treatment
1	48	M	Pulmonary infection (pneumonia)	Antibiotics
2	31	M	Pulmonary infection (pneumonia)	Antibiotics
3	51	M	Pulmonary infection (pneumonia)	Antibiotics
4	52	M	Pulmonary infection (pneumonia)	Antibiotics, steroid
5	49	W	Pulmonary infection (pneumonia)	Antibiotics
6	55	M	Pulmonary infection (pneumonia)	Antibiotics
7	48	W	Pulmonary infection (pneumonia)	Antibiotics
8	72	M	Pulmonary infection (tuberculosis)	Antitubercular agents
9	58	M	Pulmonary infection (tuberculosis)	Antitubercular agents
10	64	W	Pulmonary infection (MAC)	Antitubercular agents
11	67	M	Lung cancer (SCLC-ED)	Chemotherapy
12	49	M	Lung cancer (NSCLC-stage I)	Surgery
13	42	M	Mediastinal tumor (pericardial cyst)	Surgery
14	54	W	Mediastinal tumor (pericardial cyst)	Surgery
15	72	W	Diaphragmatic sarcoma	Surgery
16	57	W	Pleural mesothelioma	Surgery, chemotherapy
17	62	M	COPD	Smoking cessation
18	58	M	BOOP	Corticosteroid
19	46	W	PAH	Medication
20	33	M	Cardiomyopathy	Medication

BOOP = bronchiolitis obliterans organizing pneumonia, COPD = chronic obstructive pulmonary disease, ED = extensive disease, M = men, MAC = *Mycobacterium avium* complex, NSCLC = nonsmall cell lung cancer, PAH = pulmonary arterial hypertension, SCLC = small cell lung cancer, W = women.

Table 3

Characteristics of 6 cases in group 2.

Clinical course	Diagnosis	M/W
Follow-up cases (n = 3)	Pleural thickening	2/0
	Cardiomegaly	0/1
No abnormality (n = 3)		2/1
Total		4/2

M = men, W = women.

Table 4

Characteristics of 83 cases in group 3.

Clinical course	Diagnosis	n	M/W
Treated cases (n = 30)	Pulmonary infection (n = 12)		
	Pneumonia	8	6/2
	Tuberculosis	3	2/1
	Pneumomycosis	1	1/0
	Thoracic tumor (n = 10)		
	Lung cancer	6	5/1
	Mediastinal tumor	4	3/1
	COPD	5	5/0
	LAM	1	0/1
	IPF	1	0/1
	Pulmonary sequestration	1	1/0
Follow-up cases (n = 38)	Pulmonary nodule	12	8/4
	Pleural thickening	1	0/1
	Coronary atherosclerosis	1	1/0
	Aortic dilation	2	2/0
	Pulmonary infection	10	4/6
	COPD	3	3/0
	Bulla	1	1/0
	Mediastinal nodule	3	3/0
	Mediastinal lymphadenopathy	3	3/0
	Tracheal polyp	2	2/0
Improvement cases (n = 7)	Pulmonary infection	7	4/3
No abnormality (n = 2)		2	2/0
Unknown cases (n = 6)		6	6/0
Total		83	62/21

COPD = chronic obstructive pulmonary disease, IPF = idiopathic pulmonary fibrosis, LAM = lymphangioleiomyomatosis, M = men, W = women.

in this study. Despite these facts, most previous studies related to thoracic diseases and health checkups have mainly focused on lung cancer and have not sufficiently addressed other thoracic tumors.

This study evaluated the usability of CR and LDCT as screening methods for all thoracic tumors. In this study, 10 of 17 thoracic tumors were found using only LDCT; this is particularly meaningful because 7 of these 10 cases were diagnosed as malignant and could be successfully treated with surgery, such as thoracoscopy, within the early stage. Although the prevalence of lung cancer is lower than that of other major cancers such as gastric, colorectal, and breast cancer (National Cancer Center Japan Report 2019: http//ganjoho.jp/reg_stat/statistics/stat/summary.html), we demonstrated that the DR of all thoracic tumors with LDCT (17/4317 = 0.39%) was higher than that of other major cancers. Even after excluding benign tumor cases (n = 6), the DR of all thoracic malignant tumors (11/4317 = 0.25%) was still high as the estimated DR of other major cancers such as colorectal (0.27%) and breast (0.29%) cancers.[11] For individuals aged ≥50 years, the DR of all thoracic tumors with LDCT (0.65%) was much higher than that of other major cancers. These results indicate that LDCT is definitely useful as a screening method for thoracic tumors in individuals, especially in those ≥50 years of age, whether they have a smoking habit. In contrast, the DR of thoracic tumors with CR was low (0.16%), and unfortunately, 3 of the 7 cases had already progressed to an advanced stage at the time of diagnosis. This means that CR screening did not contribute to the early detection of thoracic tumors.

Some important aspects should also be discussed when evaluating the usability of CR and LDCT as screening methods. There are false-positive scans, radiation exposure, and costs. First, false-positive findings of benign lesions often occur, especially during LDCT screening.[18] In fact, many of the suspected thoracic tumors in group 3 (n = 18) were not diagnosed with tumors. These cases were followed up periodically owing to small pulmonary or mediastinal nodules detected with LDCT screening, which was much higher than that detected with CR screening (n = 4). These findings are common during LDCT screening, and clinicians, and patients are often distressed during the follow-up period. Second, radiation exposure is another important factor to consider. CT imaging involves more radiation exposure than CR imaging. The average dose for a conventional standard chest CT is approximately 7–8 mSv, which results in high exposure to radiation.[19] However, the average dose for LDCT imaging is approximately 1.5 mSv, which is half the dose of the natural ambient exposure of approximately 3 mSv per year.[20] In addition, the average dose of radiation exposure with LDCT is less than that of the upper gastrointestinal series (UGI), which is widely performed every year during health checkups in Japan.[21] Even if LDCT screening is repeated every 3 months, the dose of radiation exposure with LDCT imaging per year is less than that of standard CT. For this reason, we consider that LDCT screening does not cause an undue increase in radiation exposure. Another aspect of LDCT screening is its high cost, which is approximately US $100 per test and much more expensive than CR screening. However, we showed that the DR of thoracic tumors on LDCT was also much higher than that on CR, and its use can result in a significant early diagnosis and treatment benefit for patients. We emphasize that LDCT provides sufficient cost versus benefit for the screening of thoracic tumors. Currently, UGI and mammography are performed for gastric and breast cancer screening over the age of 40 years, respectively, in Japan; however, LDCT has not been recommended for lung cancer or other thoracic tumor screening. We demonstrated that LDCT has a higher DR of thoracic tumors than other major cancers. In addition, LDCT takes less time and is less uncomfortable than UGI, and it is less painful than mammography. Therefore, we recommend using LDCT for all thoracic tumor screening, especially for individuals aged ≥ 50 years.

In this study, we investigated the usability of CR and LDCT in the screening of COPD, and 13 cases with initial signs of COPD were identified using CR and/or LDCT. Among them, 8 cases were detected by LDCT only, which could lead to some early implementation of smoking cessation treatment. We also found that the DR of COPD with LDCT (0.30%) was higher than that of lung cancer (0.19%). It is noteworthy that the DR of COPD in those aged ≥50 years was remarkably high (0.54%), and this DR was sufficiently high even if we did not focus on smoking habits in this age group. These results indicate that LDCT screening is very useful for the early detection of COPD and lung cancer, especially in those aged ≥50 years. COPD is a leading cause of morbidity and mortality worldwide, and recently, a considerable number of people have been diagnosed with COPD.[22,23] However, COPD is still not well recognized in Japan despite its estimated prevalence of 5.3 million.[24] Although a number of etiological studies have been conducted, cigarette smoking is the most commonly encountered and readily identifiable risk factor for COPD.[25–28] Nowadays, smoking cessation is a very important treatment to prevent the exacerbation of COPD.[29,30] We have high expectations regarding the early detection and implementation of smoking cessation treatment for COPD resulting from LDCT screening. We believe that this approach also supports the preventive intervention of rapidly spreading coronavirus disease 2019 severity in patients with COPD.[31–35]

Table 5

Summary of 30 cases in group 3 who received medical treatment.

Case (n)	Age (yr)	Sex (M/W)	Diagnosis	Treatment
1	42	M	Pulmonary infection (pneumonia)	Antibiotics
2	40	M	Pulmonary infection (pneumonia)	Antibiotics
3	54	M	Pulmonary infection (pneumonia)	Antibiotics
4	55	W	Pulmonary infection (pneumonia)	Antibiotics
5	63	M	Pulmonary infection (pneumonia)	Antibiotics
6	50	M	Pulmonary infection (pneumonia)	Antibiotics
7	56	M	Pulmonary infection (pneumonia)	Antibiotics
8	51	W	Pulmonary infection (pneumonia)	Antibiotics
9	44	M	Pulmonary infection (pneumonia)	Antibiotics
10	61	M	Pulmonary infection (tuberculosis)	Antitubercular agents
11	34	W	Pulmonary infection (tuberculosis)	Antitubercular agents
12	38	M	Pulmonary infection (pneumomycosis)	Antifungal agent
13	58	M	Lung cancer (NSCLC-stage I)	Surgery
14	55	M	Lung cancer (NSCLC-stage I)	Surgery
15	64	M	Lung cancer (NSCLC-stage I)	Surgery
16	62	M	Lung cancer (NSCLC-stage I)	Surgery
17	48	W	Lung cancer (NSCLC-stage I)	Surgery
18	70	M	Lung cancer (NSCLC-stage I)	Surgery
19	63	M	Mediastinal tumor (liposarcoma)	Surgery
20	56	M	Mediastinal tumor (bronchogenic cyst)	Surgery
21	40	W	Mediastinal tumor (teratoma)	Surgery
22	51	M	Mediastinal tumor (thymoma)	Surgery
23	41	M	COPD	Smoking cessation
24	55	M	COPD	Smoking cessation
25	54	M	COPD	Smoking cessation
26	70	M	COPD	Smoking cessation
27	50	M	COPD	Smoking cessation
28	47	W	LAM	Medication
29	65	W	IPF	Corticosteroids
30	46	M	Pulmonary sequestration	Surgery

COPD = chronic obstructive pulmonary disease, IPF = idiopathic pulmonary fibrosis, LAM = lymphangioleiomyomatosis, M = men, NSCLC = nonsmall cell lung cancer, W = women.

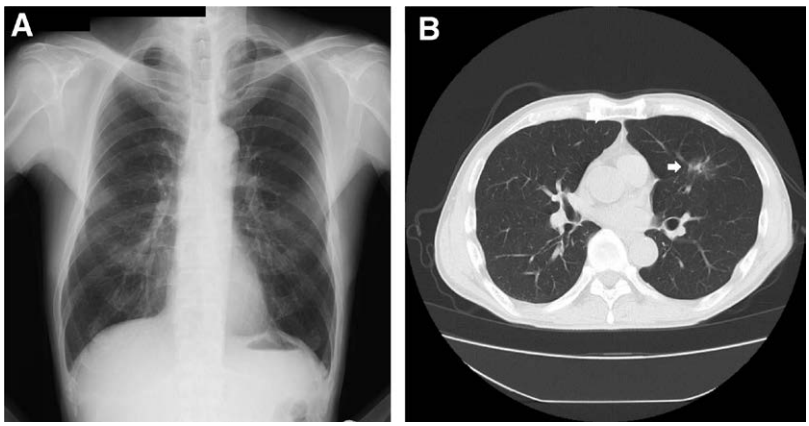

Figure 3. (A) CR of Case 15 described in Table 5. There was no abnormal opacity. (B) LDCT of Case 15 described in Table 5. There was a ground-glass opacity on the left lower lobe (white arrow). This case was diagnosed as stage I lung cancer. CR = chest radiography, LDCT = low-dose computed tomography.

The most frequently identified cause of abnormal opacity was pulmonary infection, and many of these cases were community-acquired pneumonia caused by *Streptococcus pneumoniae*, *Staphylococcus aureus*, or *Mycoplasma*, which usually improve spontaneously. In fact, among the 29 cases in group 3, 17 cases improved spontaneously or were followed up without the use of medication, and most of the treated patients received oral antibiotics as outpatient care. There were 3 cases of tuberculosis or pneumomycosis that required treatment with specific antibiotics. We consider that LDCT can reveal tiny inflammatory changes that are not seen on CR, and many of these cases might improve spontaneously. Therefore, LDCT screening for pulmonary infections is probably less useful than screening for thoracic tumors and COPD. In addition, pulmonary infections frequently occur in individuals aged ≤49 years, as mentioned above, and are not mainly found in individuals aged ≥50 years, in contrast to thoracic tumors and COPD. These results suggest that CR screening is suitable and sufficient for the detection of pulmonary infections, especially in the young age group, as has been previously reported.[36,37]

In this study, other thoracic diseases such as BOOP, PAH, LAM, IPF, and pulmonary sequestration were occasionally found on CR and/or LDCT. Although LDCT was useful in detecting some cases that were not identified with CR, these diseases are less frequently encountered than infection, tumors, and COPD; therefore, the usefulness of LDCT in the yearly screening of such diseases is limited.[38–40]

CR is useful for imaging cardiovascular changes. In fact, CR could detect more cases of cardiomegaly (n = 4) than

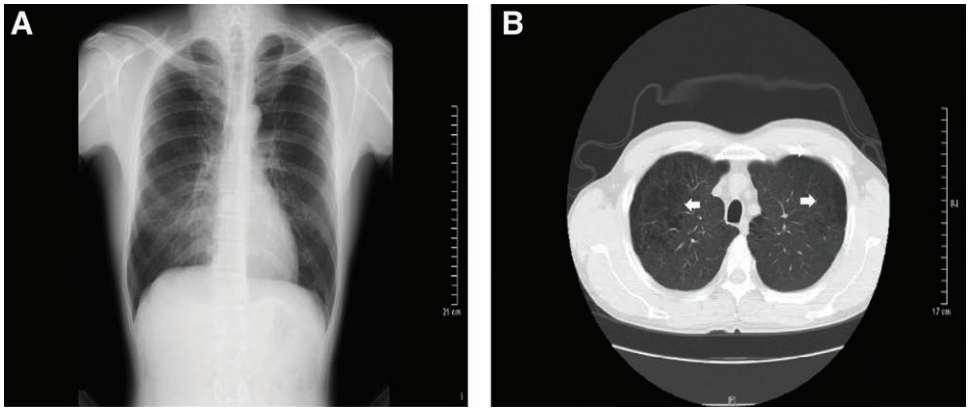

Figure 4. (A) CR of Case 24 described in Table 5. There was no abnormal opacity. (B) LDCT of Case 24 described in Table 5. There were a number of low attenuation areas on the bilateral upper lobes (white arrows). This case was diagnosed as COPD. COPD = chronic obstructive pulmonary disease, CR = chest radiography, LDCT = low-dose computed tomography.

sliced LDCT imaging (n = 3). We consider that CR is still the most commonly used imaging modality for lung infection and cardiovascular change, especially in individuals aged ≤49 years due to its widespread availability, low radiation exposure, low cost, and rich literature addressing automated detection.[41]

4.1. Study limitations

The limitations of this study include the following: first, the majority of the subjects who underwent a health checkup were excluded as they had not undergone LDCT; therefore, a long time period was needed to collect the current data despite its cross-sectional study design. Second, we could not obtain the outcomes in some cases, and several unknown cases were identified in this study.

5. Conclusion

LDCT screening is a useful method for facilitating the early detection and treatment of thoracic tumors and COPD, especially in those aged ≥50 years. However, its usability is limited to other thoracic diseases. CR is the most commonly used imaging modality for thoracic diseases and is especially suitable for individuals aged ≤49 years.

All relevant data are within the article.

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Author contributions

Methodology and Writing: This study was designed and conducted by I. kasuga.

Resources: This study was resourced by O. Ohtsubo.

Investigation: Interpretation of LDCT was performed by I. Kasuga (pulmonologist, internal medicine, and health check-up specialist) and M. Okayama (radiologist). Interpretation of CR was mainly performed by all other authors as follows: H. Maezawa (infectious disease specialist), S. Gamo (health check-up specialist), Y. Yokoe (internal medicine and health check-up specialist), Y. Yanagihara (cardiologist and internal medicine specialist), T. Sugiyama (health check-up specialist), and M. Tokura (external medicine specialist).

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